inputting an image of a face of a subject having a practicular face pose;

inputting a generic three dimensional face model;

creating a specific three dimensional face model of the specific subject by deforming the generic face model to conform to the shape of the face depicted in the input image;

using a spline surface construction technique to smooth the specific face model;

using a texture mapping technique to endow textural detail to the smoothed face model;

synthesizing various face pose images using the specific 3-D face model; and

employing the synthesized images as training images to train a recognizer.

REMARKS

The application is believed to be in condition for allowance because the claims are non-obvious over the cited art. The following paragraphs provide the justification for these beliefs. In view of the following reasoning for allowance, the applicants hereby respectfully request further examination and reconsideration of the subject application.

Specification.

The specification was objected to because the application number and filing date of a co-pending application on page 21 were missing. Applicants have amended the specification to include this information. It is believed that this amendment has corrected this informality.

The Section 112, Second Paragraph Rejection of Claims 11 and 17.

Claims 11 and 17 stand rejected under 35 USC 112, second paragraph, as being indefinite. It is believed that the foregoing amendments to claim 11 and 17 have clarified any indefiniteness that existed in the original claim language.

The Examiner contends that Claims 11 and 17 lack antecedent basis. The applicants have amended these claims to provide the proper antecedent basis.

It is believed the amended claims now fulfill the requirements of 35 USC 112, second paragraph, as they particularly point out and distinctly claim the subject matter which the applicant regards as the invention. Therefore, it is respectfully requested that the rejection of Claims 11 and 17 be reconsidered based on the above-quoted amended claim language.

The 35 USC 103 Rejection of 1-11 and 16.

Claims 1-11 and 16 were rejected under 35 USC 103(a) as being unpatentable over Yan et al's publication, in view of Kung, U.S. Patent No. 5,850,470. The Examiner stated that Yan discloses a deformable model of a realistic face but does not teach the training of a 3D face recognizer for face recognition. However, the Examiner further contended that Kung teaches a facial recognition system using a data base of images to train the recognizer. The applicants respectfully disagree with this contention of obviousness.

In order to deem the applicants' claimed invention unpatentable under 35 USC 103, a prima facie showing of obviousness must be made. To make a prima facie showing of obviousness, all of the claimed elements of an applicant's invention must be considered, especially when they are missing from the prior art. If a claimed element is not taught in the prior art and has advantages not appreciated by the prior art, then no prima facie case of obviousness exists. The Federal Circuit court has stated that it was error not to distinguish claims over a combination of prior art references where a material limitation in

the claimed system and its purpose was not taught therein (*In Re Fine*, 837 F.2d 107, 5 USPQ2d 1596 (Fed. Cir. 1988)).

The applicants claim a system and method that allows for face recognition even in the absence of a significant amount of training data. Further, it can recognize faces at various pose angles even without actual training images exhibiting the corresponding pose. This is accomplished by synthesizing training images depicting a subject's face at a variety of poses from a small number (e.g., two) of actual images of the subject's face. The claimed invention overcomes the limitations in prior face recognition systems by a system and method that only requires the capture of one or two images of each person being recognized. Although, the capture of two training images of a person sought to be recognized is preferred, one training image will allow for the synthesis of numerous training images.

The system and process according to the present invention also employs a generic 3-D graphic face model. The generic face model is preferably a conventional polygon model that depicts the surface of the face as a series of vertices defining a "facial mesh".

Once the actual face image(s) and the generic 3-D graphic face model have been input, an automatic deformation technique is used to create a single, specific 3-D face model of the subject from the generic model and images. More specifically, to deform the generic face model to the specific model, an auto-fitting technique is adopted. In this technique, the feature point sets are extracted from the subject's frontal and profile images. Then the generic face model is modified to the specific face model by virtue of comparison and mapping between the two groups of feature point sets. In the preferred frontal/profile embodiment of the present invention, symmetry of the face is assumed. For example, if the right-side profile is input, it is assumed the left side of the face mirrors the right side. If more than two images are used to create the specific model, it is preferred to use the automatic deformation technique to create a 3-

D model using two of the images (preferably the frontal/profile images) and the generic model to create a specific 3-D face model and then to refine the model using the additional images. Alternately, all images could be used to create the 3-D model without the refinement step. However, this would be more time consuming and process intensive.

A subdivision spline surface construction technique is next used to "smooth" the specific 3-D face model. Essentially, the specific 3-D face model is composed of a series of facets which are defined by the aforementioned vertices. This facet-based representation is replaced with a spline surface representation. **The spline surface representation essentially provides more rounded and realistic surfaces to the previously faceted face model using Bézier patches.**

Once the subdivision spline surface construction technique is used to "smooth" the specific 3-D face model, a multi-direction texture mapping technique is used to endow texture or photometric detail to the face model to create a texturized, smoothed, specific, 3-D face model. This technique adds realism to the synthetic human faces. Essentially, the input images are used to assign color intensity to each pixel (or textel) of the 3-D face model using conventional texture mapping techniques. More particularly, for each Bézier surface patch of face surface, a corresponding "texture patch" is determined by first mapping the boundary curve of the Bézier patch to the face image. In the preferred embodiment employing frontal and profile input images, the face image chosen to provide the texture information depends on the preferred direction of the Bézier patch. When the angle between the direction and the Y-Z plane is less than 30 degrees, the frontal face image is used to map; otherwise the profile image is used. In addition, facial symmetry is assumed so the color intensities associated with the profile input image are used to texturize the opposite side of the 3-D model.

Once a 3-D face model of a specific subject is obtained, realistic individual virtual

faces or 2-D face images, at various poses, can be easily synthesized using conventional computer graphics techniques (for example, using CAD/CAM model rotation). These techniques are used to create groups of training images for input into a "recognizer" to allow for training of the recognizer. It is also optionally possible to take the generated images and synthetically vary the illumination to produce each image at various illuminations. In this way, subjects can be recognized regardless of the illumination characteristics associated with an input image.

In contrast, Yan teaches a human face generation technique using a three-dimensional deformation technique. The deformation technique allows interactive alignment of features in the general geometric face model with the features of the multi-direction images of the specific human face which are pre-provided by the animator. The deformation result also provides an approach to obtain models of facial expression. Yan's modeling **technique requires at least three input images** of a specific human face—a frontal view, a left side and a right side—to model a given face. Additionally, **no spline smoothing is taught in the cited Yan reference**. Furthermore, as the Examiner stated Yan does not teach the training of a 3D face recognizer for face recognition. More importantly, the cited **Yan reference does not teach the training of a 3D face recognizer using synthesized images**.

Granted, the Examiner states that Yan teaches spline surface construction at page 857, col. 2, lines 25-27. The passage states,

> "When move a vertex to match the specific feature point in the image, the deformation algorithm automatically calculate the new position of the relative vertexes around the moved vertex. This simulate the plastic visco-elastic behavior of the facial skin."

However, no mention is made in this passage of using splines. In fact, nowhere in the Yan reference is the use of splines mentioned or taught.

Kung discloses a system for automatically detecting and recognizing the identity of a deformable object such as a human face, within an arbitrary image scene. The system comprises an object detector implemented as a probabilistic DBNN, for determining whether the object is within the arbitrary image scene and a feature localizer also implemented as a probabilistic DBNN, for determining the position of an identifying feature on the object such as the eyes. A feature extractor is coupled to the feature localizer and receives coordinates sent from the feature localizer which are indicative of the position of the identifying feature and also extracts from the coordinates information relating to other features of the object such as the eyebrows and nose, which are used to create a low resolution image of the object. A probabilistic DBNN based object recognizer for determining the identity of the object receives the low resolution image of the object inputted from the feature extractor to identify the object. The system 10 comprises a video camera 12 for inputting an arbitrary image scene 11 with 320 by 240 pixels. A DBNN-based face detector 14 is coupled to the video camera 12 and includes a memory 16 which operates as a database for storing images of different human faces. The face detector 14 determines whether a face is within the arbitrary image scene 11. The data stored in the face database 16 is used to train the face detector 14. During training, updated network weighting parameters and thresholds are stored in the face database 16. Kung **does not use a synthesized database to train a face recognizer, nor does Kung mention the use of splines in his process of identifying an object. Additionally, Kung requires the use of many input images to form his database.**

this is taught

this is in claim 2 not 1

Thus, the applicants have claimed elements not taught in the cited art and which have advantages not recognized therein, namely the ability to train a face recognizer with only one input image and using splines to improve the synthesized result. Accordingly, no prima facie case of obviousness has been established in accordance with the holding of *In Re Fine*. This lack of prima facie showing of obviousness means that the rejected claims are patentable under 35

USC 103 over Yan in view of Kung. It is, therefore, respectfully requested that the rejection of Claims 1-11 and 16 be reconsidered based on the novel claim language:

> " A computer-implemented process for face recognition, comprising using a computer to perform the following process actions...inputting **an image** of a face of a subject sought to be recognized having a particular face pose; inputting a generic three dimensional face model; creating a specific three dimensional face model of the specific subject sought to be recognized by deforming the generic face model to conform to the shape of the face depicted in the input image; **synthesizing various face pose images** using the specific 3-D face model; and **employing the synthesized images as training images to train a recognizer**. " (emphasis added)

The 35 USC 103 Rejection of Claims 12-15.

Claims 12-15 were rejected under 35 USC 103(a) as unpatentable over Yan, in view of Kung, and in further view of Deering, U.S. Patent No. 6,525,723, hereinafter Deering. The Examiner stated that Yan and Kung do not teach assigning the color intensity of each pixel in order to perform textural analysis. However, the Examiner contended that Deering teaches this feature. The Examiner further contended it would have been obvious to have modified the Yan and Kung systems by Deering's color intensity calculations. The applicants respectfully traverse this contention of obviousness.

The applicants' claimed invention allows for face recognition even in the absence of a significant amount of training data. Further, it can recognize faces at various pose angles even without actual training images exhibiting the corresponding pose. This is accomplished by synthesizing training images depicting a subject's face at a variety of poses from a small number (e.g., two) of actual images of the subject's face. The claimed invention overcomes the limitations in prior face recognition systems by a

system and method that only requires the capture of one or two images of each person being recognized. Although, the capture of two training images of a person sought to be recognized is preferred, one training image will allow for the synthesis of numerous training images.

Neither Yan, Kung, nor Deering disclose a system and method that allows the training of a recognition system that recognizes a person based on a single image by employing this image to generate a synthesized database. Nor does Yan in combination with Kung and Deering recognize the advantages of the applicants' claimed invention. Namely, namely neither Yan, Kung, nor Deering, alone or in combination, teach the applicants' claimed system and method of face recognition using a training database made of synthesized images generated from as little as one image.

Thus, the applicants have claimed elements not taught in the cited art and which have advantages not recognized therein. Accordingly, no prima facie case of obviousness has been established in accordance with the holding of *In Re Fine*. This lack of prima facie showing of obviousness means that the rejected claims are patentable under 35 USC 103 over Yan in combination with Kung and Deering. As such, it is respectfully requested that the rejection of Claims 12-15 be reconsidered based on the above-quoted claim language.

The 35 USC 103 Rejection of Claim 17.

Claim 17 was rejected under 35 USC 103(a) as unpatentable over Yan, in view of Kung and in further view of Georghiades, June 1999. The Examiner stated that Yan and Kung do not teach varying illumination to produce synthesized images. However, the Examiner contended that Georghiades teaches this feature. The Examiner further contended it would have been obvious to have modified the Yan and Kung systems by Georghiades' teachings. The applicants respectfully traverse this contention of

obviousness.

As discussed previously, the applicants' claimed invention allows for face recognition even in the absence of a significant amount of training data. Further, it can recognize faces at various pose angles even without actual training images exhibiting the corresponding pose. This is accomplished by synthesizing training images depicting a subject's face at a variety of poses from a small number (e.g., two) of actual images of the subject's face. Although, the capture of two training images of a person sought to be recognized is preferred, one training image will allow for the synthesis of numerous training images.

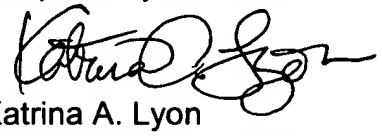
Neither Yan, Kung, nor Georghiades disclose a system and method that allows the training of a recognition system to recognize a person based on a single image by employing this image to generate a synthesized database. Nor does Yan in combination with Kung and Georghiades recognize the advantages of the applicants' claimed invention. Namely, namely neither Yan, Kung, nor Georghiades, alone or in combination, teach the applicants' claimed system and method of face recognition using a training database made of synthesized images generated from as little as one image.

Thus, the applicants have claimed elements not taught in the cited art and which have advantages not recognized therein. Accordingly, no prima facie case of obviousness has been established in accordance with the holding of *In Re Fine*. This lack of prima facie showing of obviousness means that the rejected claim is patentable under 35 USC 103 over Yan in combination with Kung and Georghiades. As such, it is respectfully requested that the rejection of Claim 17 be reconsidered based on the above-quoted claim language.

Summary.

In summary, it is believed that the claims are in condition for allowance. Reconsideration of the rejection of Claims 1-24 is respectfully requested. Allowance of these claims at an early date is courteously solicited.

Respectfully submitted,



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